



UM10861

SSL5231DB1246 230 V/10 W buck-boost dimmable A19 LED driver demo board

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User manual

Document information

Info	Content
Keywords	SSL5231DB1246, SSL5231T, non-isolated buck-boost topology, LED driver controller, external MOSFET switch, A19 lamp shape dimmable applications, SO8 package
Abstract	This user manual describes the performance, technical data, and the connections of the SSL5231DB1246 demo board, using a non-isolated buck-boost topology. The SSL5231T (SO8 package) is used as driver controller IC. The SSL5231DB1246 demo board is designed for dimmable A19 lamp shape applications. It operates at 230 V (AC), with an output voltage approximately 60 V.



Revision history

Rev	Date	Description
v.1	20150115	first issue

Contact information

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard



The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual describes the operation of the SSL5231DB1246 demo board, featuring the MOSFET driver controller SSL5231T. The SSL5231DB1246 demo board is a 230 V/10 W non-isolated buck-boost dimmable LED driver application.

The SSL5231DB1246 demo board is designed for driving LED loads with a nominal voltage level of 60 V and 10 W input power.

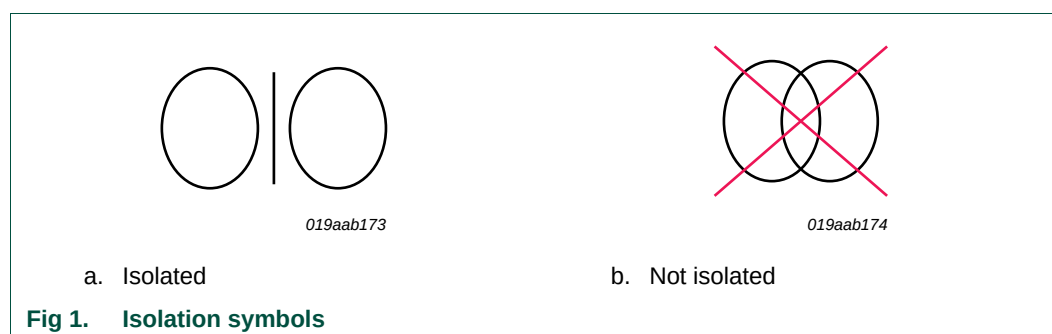
The SSL5231DB1246 demo board provides a simple and highly efficient solution for Solid-State Lighting (SSL) applications.

1.1 Features

- A19 form-factor applications
- Supports most available leading-edge and trailing-edge dimmers
- Deep dimming level
- Flicker-free dimming
- Open/short LED string protection
- OverCurrent Protection (OCP)
- OverTemperature Protection (OTP)
- Power Factor (PF) > 0.75
- Efficiency > 85 % at 230 V (AC) input
- Compliant with IEC61000-3-2 harmonic standard
- Compliant with EN55015 conducted EMI

2. Safety warning

The board must be connected to the mains voltage. Avoid touching the board during operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation of the mains phase using a variable transformer is always recommended. [Figure 1](#) shows the symbols on how to recognize these devices.



3. Specifications

Table 1. SSL5231DB1246 specifications

Symbol	Parameter	Value
V_{mains}	AC mains supply voltage	230 V (AC); $\pm 10\%$
P_{in}	input power	10 W
V_{LED}	LED output voltage	60 V
I_{LED}	LED output current	≈ 140 mA
$I_{\text{LED(ripple)}}$	LED output current ripple	$< 25\%$ (100 Hz)
$\Delta I_{\text{LED}}/\Delta V_{\text{mains}}$	line regulation	$< 3\%$ (V_{mains} : $\pm 10\%$)
$\Delta I_{\text{LED}}/\Delta V_{\text{LED}}$	load regulation	$\pm 5\%$ at V_{LED} ; $\pm 15\%$
η	efficiency	85 %; at 230 V (AC)/50 Hz
PF	power factor	> 0.75 ; at 230 V (AC)/50 Hz
T_{oper}	operating temperature	$-40\text{ }^{\circ}\text{C}$ to $+105\text{ }^{\circ}\text{C}$
	board dimensions	90 mm $\times$ 40 mm
	conducted ElectroMagnetic Interference (EMI)	EN55015
	IEC61000-3-2	Class D (for $P_{\text{in}} < 25$ W limit)
dimmer compatibility (stable light output above on/off point)		80 % dimmer compatibility

4. Board photographs

[Figure 2](#) shows the top view and bottom view of the SSL5231DB1246 demo board. At the left side connector of the board ([Figure 2\(a\)](#)), the AC mains (230 V) must be connected. At the right connector, the LED load (60 V) must be connected. The inner part of the board can be broken out and has an A19 lamp form factor.

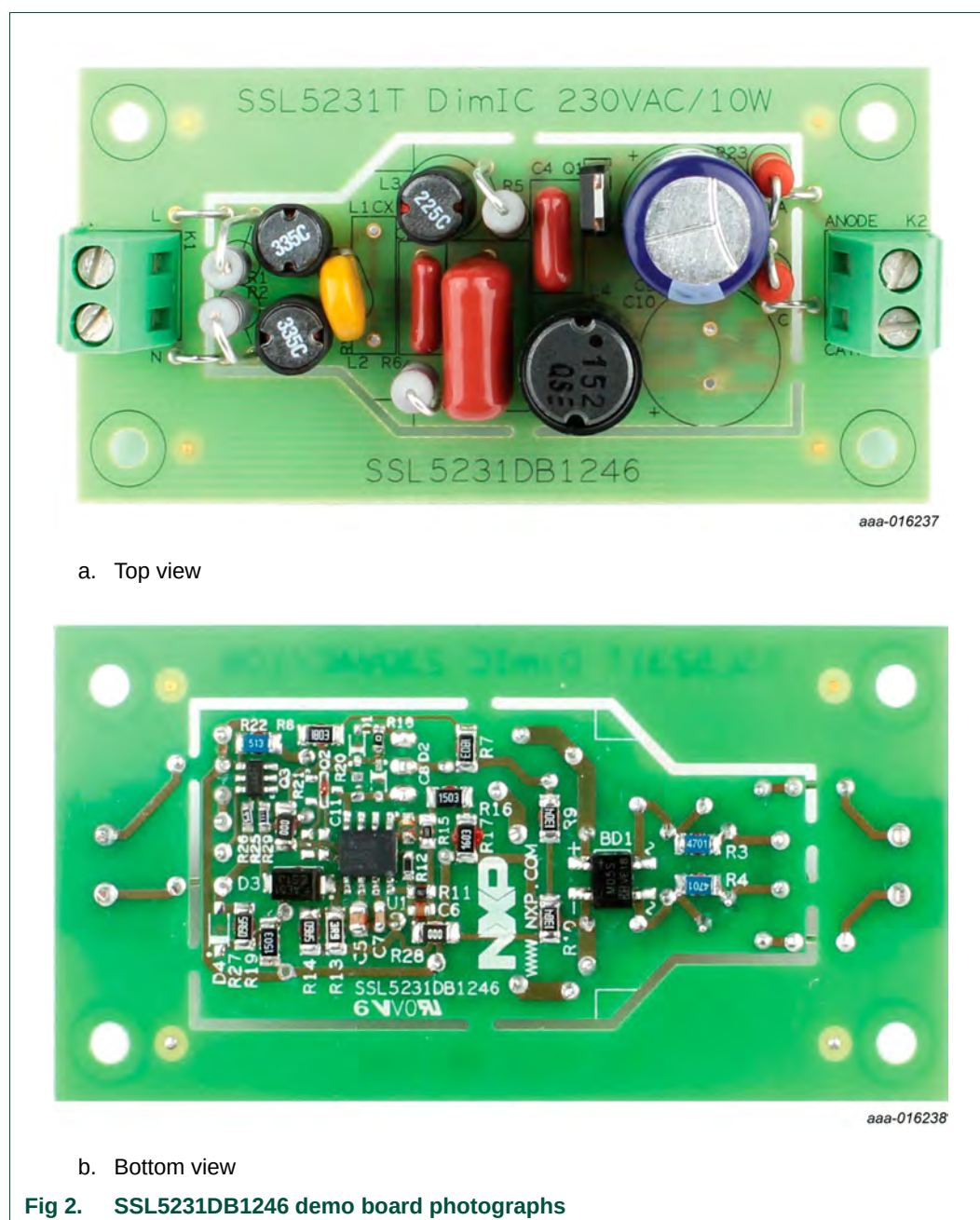


Fig 2. SSL5231DB1246 demo board photographs

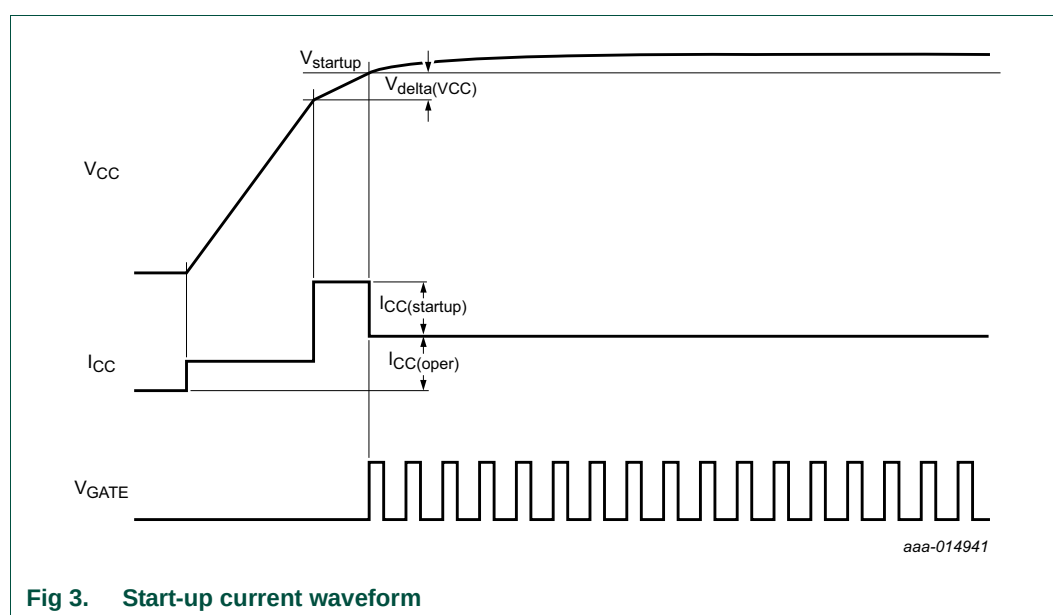
5. Functional description

5.1 Input filtering

The mains input circuitry (see [Figure 10](#)) filters the switching current from the buck-boost converter to the mains AC. To meet the audible noise requirements and to be able to connect the required lamps per dimmer, the mains input circuits limits the inrush current. A provision has been added for improved dimmer triac latching.

5.2 Efficiency improvement for universal mains

Resistors R7 and R8 supply the current for the SSL5231T (see [Figure 11](#)). the IC draws an additional start-up current ($I_{CC(startup)}$) just before V_{CC} reaches the start-up voltage level ($V_{startup}$). The supply current in operation is therefore lower than during start-up conditions. It prevents lamp flicker when the mains voltage is increased or decreased slowly. This mechanism in combination with an efficiency improvement increases the dimming performance. [Figure 3](#) shows the start-up current waveform.



5.3 Deep dimming improvement

To improve the deep dimming performance, a secondary side bleeder circuit has been added (see schematic in [Section 7.3](#)). When the LED current lowers during dimming, a part of the LED output current is shunted via resistors R23 and R24.

5.4 Output open and output short protection

The driver board is protected when the LED load is accidentally left open. When the LED load is accidentally left open, the output voltage increases. When the OverVoltage Protection level is reached on the DEMOVP pin, the OVP protection is activated. This OVP protection (OVP), is a non-latched protection. It recovers when the LED string is reconnected. Resistors R15, R16, and R17 determine the OVP level. The voltage rating of output capacitor C9 and C10 must be higher than the DC level which occurs when the LED load is accidentally left open.

The measured OVP level is about 99 V.

Remark: Do not reconnect the LED string directly after an OVP condition. It can permanently damage the LEDs. Switch off the mains and wait until the output capacitor is discharged.

During an output short circuit, the maximum ISNS voltage limits the primary converter current. The converter frequency drops to its absolute minimum. This mode is safe and the input power is low. It is valid when the short happens before the mains supply is activated. When the short happens during normal operation, components R25, R26, R27, and Q3 of the secondary side bleeder (see [Figure 12](#)) break safely before the converter frequency drops to its absolute minimum. By adding diode D4 (1N4148 in parallel to R27), the save mode is entered without damaging mentioned components.

5.5 ElectroMagnetic Interference (EMI) precautions

For optimal EMI performance, the way of mounting of L1, L2, L3, and L4 are important.

- Buck-boost inductor L4:

The start of winding, which is the wire closest to the core (marked with a dot on the coil and the schematic) must be connected to the switching side of the converter. In this case, it must be connected to the IC ground. The outer part of the winding acts as a shield for the inner part of the winding, which is operated at a high frequency and a high voltage. The inductor shields itself by the outer part of the winding.

- Filter inductor L3:

The start of the winding, which is the wire closest to the core (marked with a dot on schematic and with shortest connection lead on the coil), must be connected to the bridge rectifier. The outer part of the winding shields the inner part of the winding.

- Filter inductors L1 and L2:

The start of the winding, which is the wire closest to the core (marked with a dot on the schematic and with the shortest connection lead on the coil) must be connected to the input resistors R2 and R1. The outer part of the windings of inductors L1 and L2 shields the inner part of the corresponding windings.

See [Figure 2\(a\)](#) for the orientation of the coils.

6. Performance

During performance tests $V_{\text{mains}} = 230 \text{ V (AC)}$ with a $\pm 20 \%$ margin, $T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$, $I_{\text{LED}} = 140 \text{ mA}$ typical, and $V_{\text{LED}} = 60 \text{ V}$ unless otherwise specified.

6.1 Efficiency

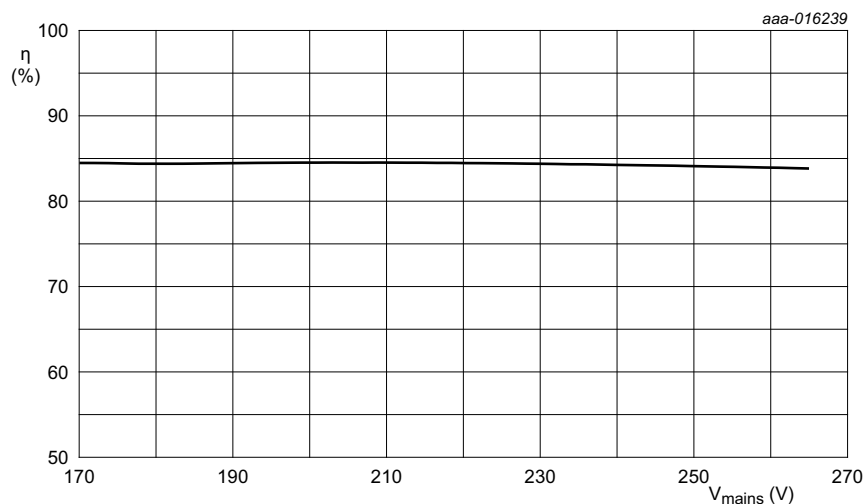


Fig 4. Efficiency as a function of mains voltage

6.2 Power factor

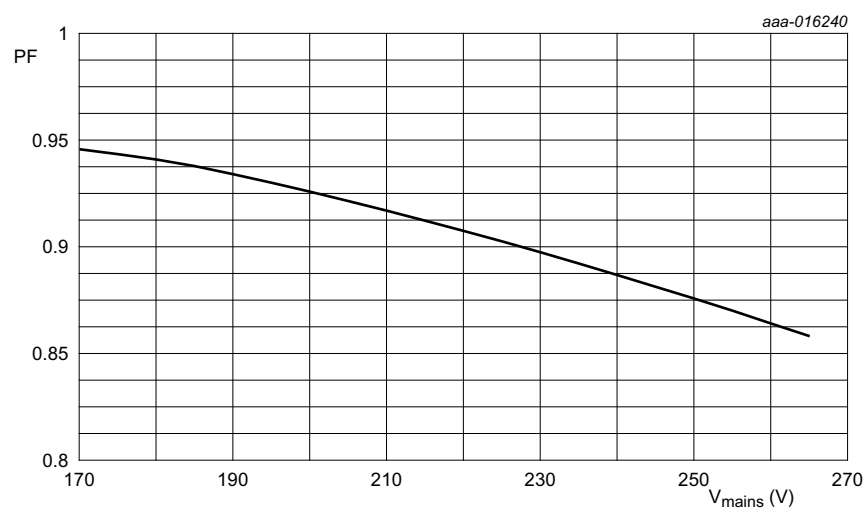
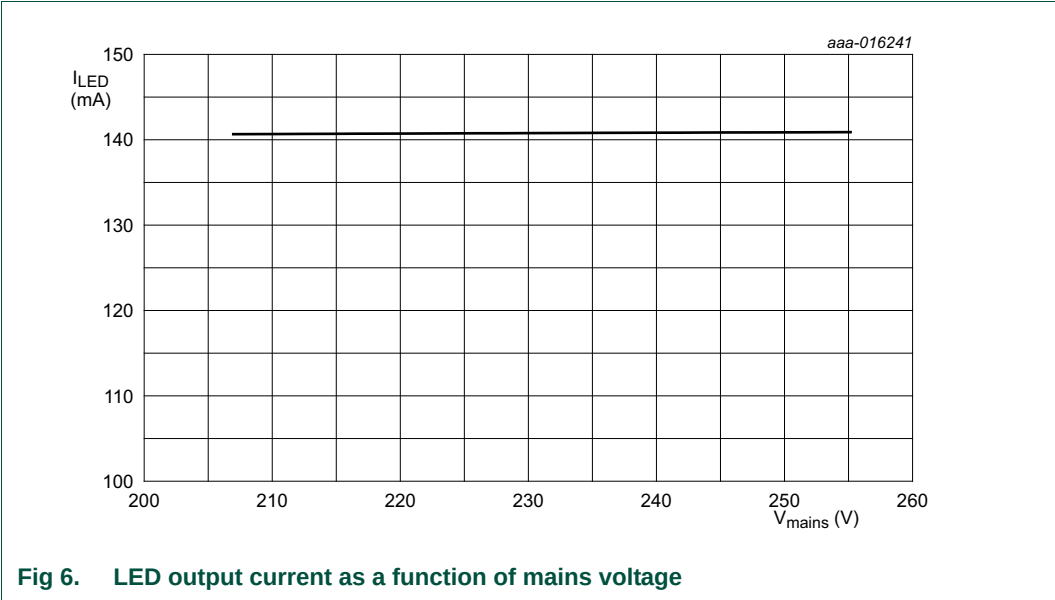
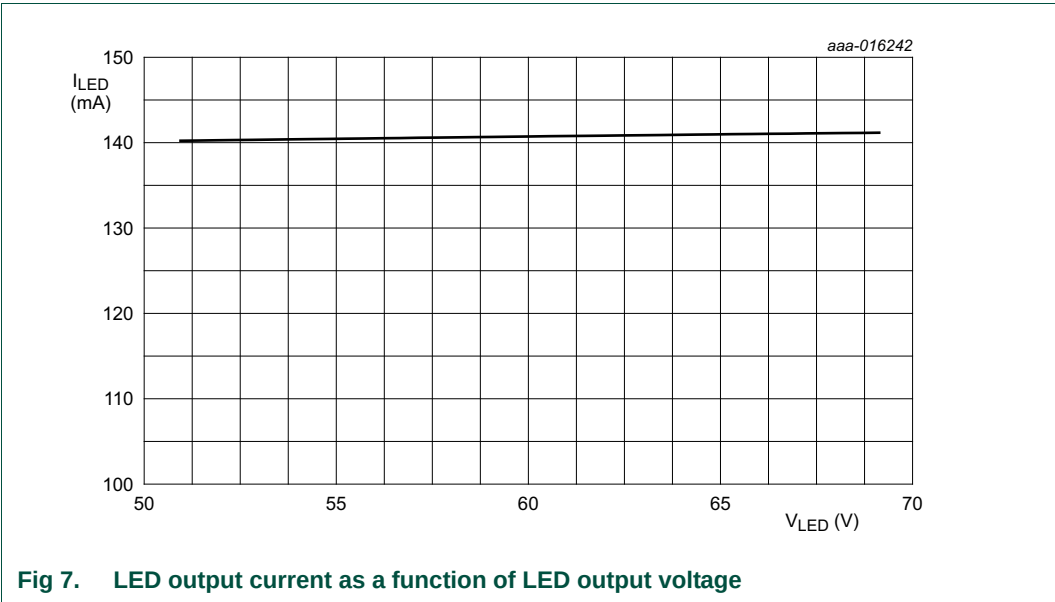


Fig 5. Power factor as a function of mains voltage

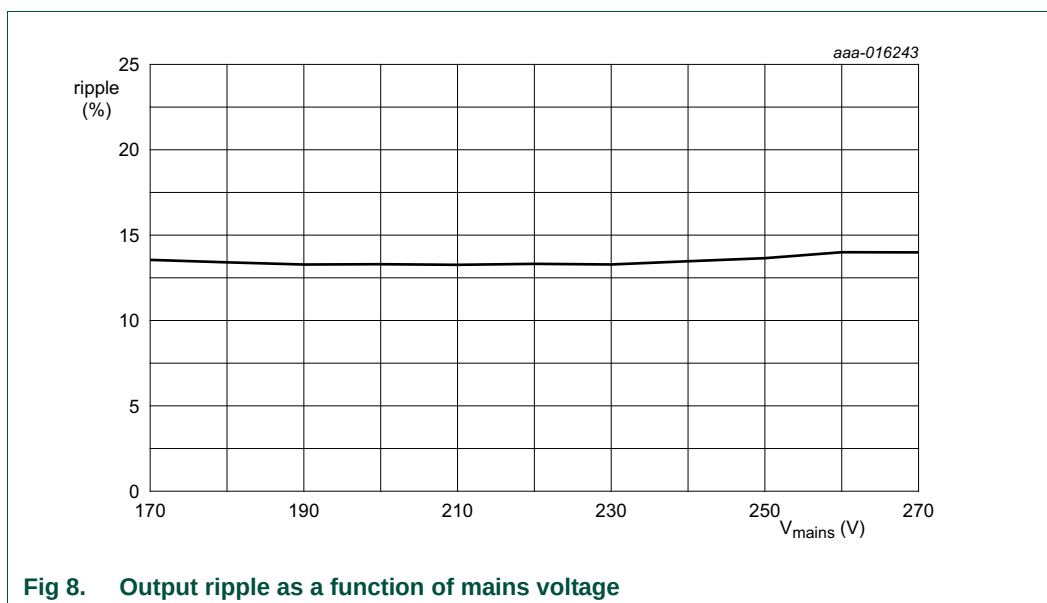
6.3 Line regulation



6.4 Load regulation

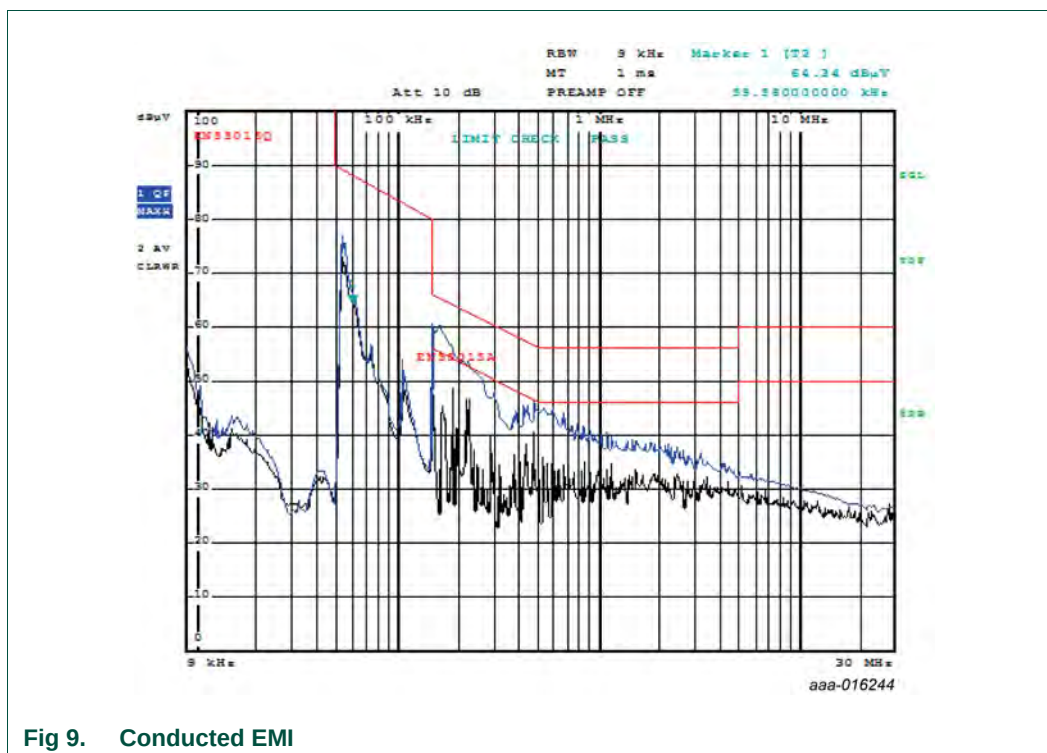


6.5 Output ripple



6.6 ElectroMagnetic Interference (EMI)

Figure 9 shows the conducted EMI result of the SSL5231DB1246 demo board.



7. Schematics

7.1 AC mains input part

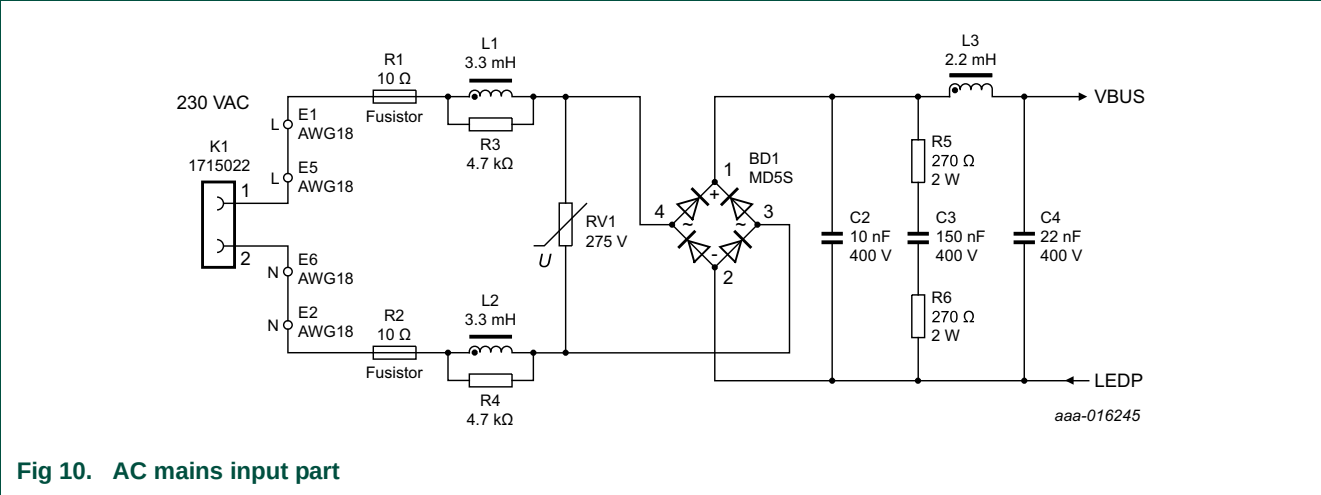


Fig 10. AC mains input part

7.2 Converter part

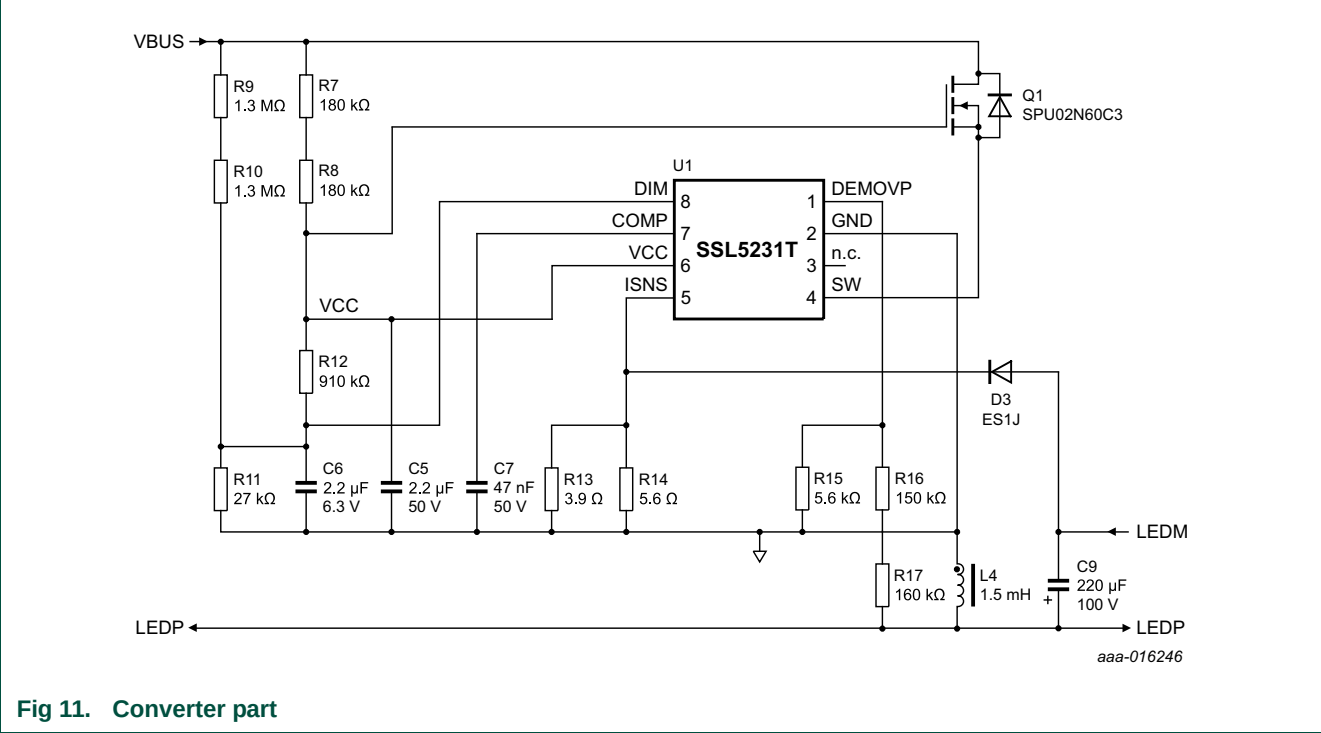


Fig 11. Converter part

7.3 Secondary side bleeder

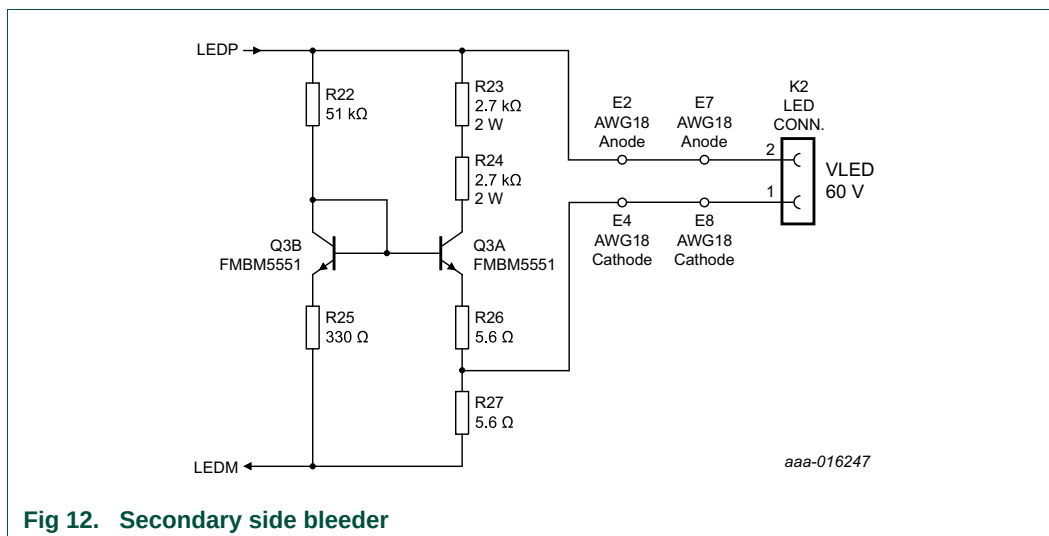


Fig 12. Secondary side bleeder

8. Bill Of Materials (BOM)

Table 2. SSL5231DB1246 bill of materials

Reference	Description and values	Part number	Manufacturer
BD1	bridge rectifier; 1000 V; 500 mA	MD5S	Rectron
C2	capacitor; 10 nF; 5 %; 400 V; PET; THT	ECQE4103JF	Panasonic
C3	capacitor; 150 nF; 5 %; 400 V; PP; THT	ECW-F4154JL	Panasonic
C4	capacitor; 22 nF; 5 %; 400 V; PET; THT	ECQE4223JF	Panasonic
C5	capacitor; 2.2 μ F; 10 %; 50 V; X5R; 0805	C2012X7R1H225K125AC	TDK
C6	capacitor; 2.2 μ F; 10 %; 6.3 V; X7R; 0603	C1608X7R0J225K080AB	TDK
C7	capacitor; 47 nF; 10 %; 50 V; X7R; 0603	-	-
C9	capacitor; 220 μ F; 20 %; 100 V; ALU; THT	ECA2AM221	Panasonic
D3	diode; 600 V; 1 A	ES1J	Fairchild
L1; L2; L3	inductor; 3.3 mH; 100 mA	22R335C	Murata
L4	inductor; 1.5 mH; 10 %; 260 mA; 2.8 Ω	ELC10E152L	Panasonic
Q1	MOSFET-N; 650 V; 1.8 A	SPU02N60C3	Infineon
Q3(AB)	transistor; NPN; 160 V; 600 mA	FMBM5551	Fairchild
R1; R2	resistor; 10 Ω ; 10 %; 2 W; THT	EMC2-10RK	Welwyn Components
R3; R4	resistor; 4.7 k Ω ; 1 %; 250 mW; 1206	-	-
R5; R6	resistor; 270 Ω ; 5 %; 2 W; MFP2	MFP2-270R JI	Welwyn Components
R7; R8	resistor; 180 k Ω ; 1 %; 250 mW; 1206	-	-
R9; R10	resistor; 1.3 M Ω ; 1 %; 250 mW; 1206	-	-
R11	resistor; 27 k Ω ; 1 %; 63 mW; 0603	-	-
R12	resistor; 910 k Ω ; 1 %; 63 mW; 0603	-	-
R13	resistor; 3.9 Ω ; 1 %; 250 mW; 1206	-	-
R14	resistor; 5.6 Ω ; 1 %; 250 mW; 1206	-	-
R15	resistor; 5.6 k Ω ; 1 %; 100 mW; 0805	-	-
R16	resistor; 150 k Ω ; 1 %; 250 mW; 1206	-	-
R17	resistor; 160 k Ω ; 1 %; 250 mW; 1206	-	-
R22	resistor; 51 k Ω ; 1 %; 250 mW; 1206	-	-
R23; R24	resistor; 2.7 k Ω ; 5 %; 2 W; ROX	PR02000202701JR500	Vishay
R25	resistor; 330 Ω ; 1 %; 63 mW; 0603	-	-
R26	resistor; 5.6 Ω ; 1 %; 63 mW; 0603	-	-
R27	resistor; 5.6 Ω ; 1 %; 250 mW; 1206	-	-
RV1	resistor; VDR; 275 V; 36 J	VDRS07H275BSE	Vishay
U1	DimIC; SSL5231T	SSL5231T	NXP Semiconductors

9. Board modifications for improved performance and reduced BOM cost

After the first board definition/realization and the current schematic, an optimization has happened concerning the performance and the BOM cost.

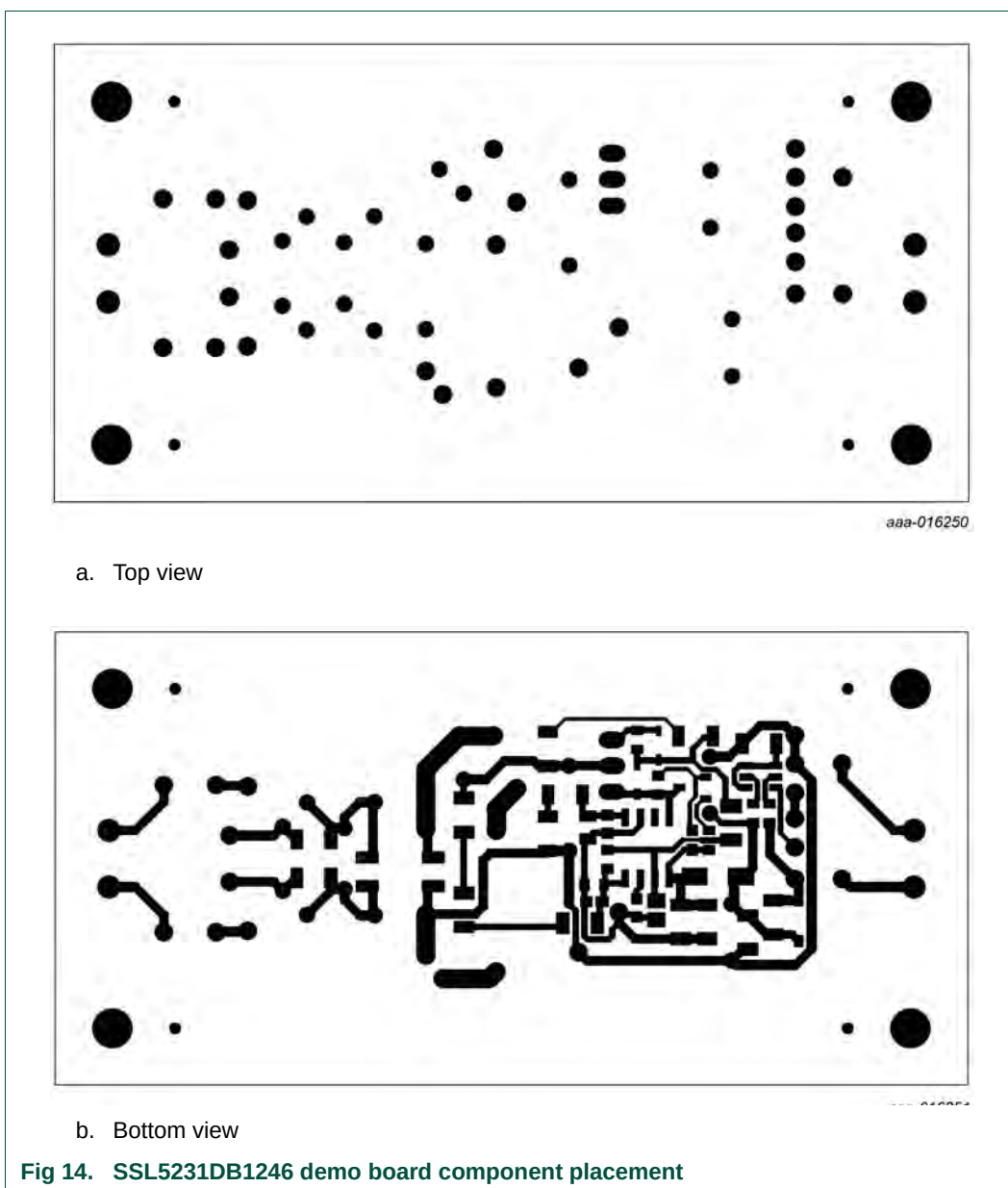
In the current board, some component numbers and places are reserved, which are not used in current optimized schematic.

[Table 3](#) shows an overview of the skipped components with the corresponding remarks.

Table 3. Board modification for improved performance and cost reduction

Part reference	Remark
C8	not mounted
C10	not mounted
C11	not mounted
CX1	not mounted
D1	not mounted
D2	not mounted
D4	not mounted
Q2	not mounted
R18	Shorted by wire or 0 Ω resistor
R19	not mounted
R20	not mounted
R21	not mounted
R28	Shorted by wire or 0 Ω resistor
R29	Shorted by wire or 0 Ω resistor

Fig 13. SSL5231DB1246 demo board layout



11. Abbreviations

Table 4. Abbreviations

Acronym	Description
EMI	ElectroMagnetic Interference
LED	Light-Emitting Diode
OCP	OverCurrent Protection
OTP	OverTemperature Protection
PF	Power Factor
SSL	Solid-State Lighting

12. References

- [1] **SSL5231T data sheet** — Compact High Power Factor Dimmable LED driver IC

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